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State of India's Environment (A Quantitative Analysis)

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Environmental trends and projections in India

1. Introduction

An examination of India, one of the world's largest and most populous countries, is essentially an examination of a microcosm of the earth. Its population spans the entire range of the income and education spectra, and its geography is a sample of almost every terrestrial climatic zone of the planet.

It is this variation that makes India's environment so interesting. India holds the dubious honor of suffering from poverty-induced environmental degradation at the same time as pollution from affluence and a rapidly growing industrial sector. In light of this dichotomy, it is a tricky task to understand the complexities behind the state of India's environment

Thus, to gain insight into what is really going on within India and its environment, one needs to look at a whole gamut of socio-economic and bio-physical parameters. This is exactly the objective of the following Environmental Information Database and the State of the Environment Report.

2. About the database

The Environmental Information Database is meant to be a convenient summary of environmental and related parameters for India for the period 1984 through 1994. Unless otherwise specified, the parameters apply the nation as a whole. Data were gathered, whenever possible, directly from appropriate Government of India officials and GOI publications, or indirectly, from sources citing the GOI. In a few cases, however, data were obtained from non-governmental sources. In the event of conflicts, GOI data was always given priority.

For certain parameters, it was not possible to obtain the necessary reliable figures, for some or all of the required years. In these cases, the respective cells in the databases were left unfilled. Moreover, in almost all instances, estimations, interpolations, and extrapolations were avoided. Only in situations where there was no ambiguity about methodology did TERI calculate figures, and those are duly noted in the reference database.

3. Selection of trends for analysis and discussion

The following sections contain discussion regarding variables from the Database, both for the period 1984 through 1994, as well as historically. As there are far too many parameters in the database to examine individually, certain ones have been selected. The variables that prove the most informative are the ones that best represent the topic under which they appear In that the discussion below is issue-oriented, grouping differs somewhat from that in the database

4. Discussion:

4.1. Demographics

This century has seen a massive growth in India's population, from 238 million persons in 1901 to 914 million in 1994 (Registrar General, 1991; World Bank, 1995) This statistic is more impressive when one considers that most of it occurred following 1950 (**Figure 1**). In particular, 150 million persons were born between 1981 and 1991 alone (ibid) India has also seen a shift in population distribution away from rural areas to urban areas, beginning in the 1930s.

The overall population growth can be attributed to a national decrease in the crude death rate, without a corresponding fall in the birth rate. As would be expected from the population figures, this occurred following 1950, which is shown in Figure 1. Although the picture may seem quite dark, there has been some improvement during the last decade. India's population has demonstrated a slight drop in its annual rate of increase, from 2.2 in 1984 percent to 1 9 percent in 1993 (ibid.). This drop can perhaps be attributed to a steady drop in India's total fertility rate, the total number of births that a woman can expect in her lifetime During the 10 year period from 1984 to 1994, total fertility fell from 4 5 children to 3 5, an impressive decline of 0 1 each year (Registrar General, 1995) This is correlated with a steady increase in the percentage of women enrolled in primary school over the same period (**Figure 2**), as well as decreases in infant mortality.

Perhaps the most impressive demographic characteristic is that of male and female life expectancies, which have almost doubled since 1950 **(Figure 3).** At present, females born today can expect to live 61 years, while males can anticipate a 60 year life (Ministry of Health and Family Welfare, 1993). Finally, there has been an improvement in infant mortality rates, which have fallen by 25 percent since 1984.

4.2 Education

(a) School enrollment Post-independence India has seen marked increases in education at all levels. This is reflected in the primary (standard 1-5) and upper primary (standard 6-8) school enrollment ratio, which has increased consistently over the past four decades (Ministry of Human Resource Development, 1995). In 1950-51 the percent primary school enrollment for boys was 60.6 and for girls was 24.8 **(Figure 4)** (Ministry of Human Resource Development, 1994/95). These parameters have increased to 114.8 and 92 6 respectively. Similarly, the percent upper primary school enrollment, which was 20.6 and 4.6 for boys and girls in 1950-51, has increased to 79 and 55 in 1994-95 respectively **(Figure 4)**. Nevertheless, the figures must be viewed with some caution, as the dropout rate in some of the cases, though decreasing, is quite high. These disparities between male and female education can also be seen in literacy rates (ibid). Although there has been a steady increase in adults who are able to read, **Figure 5** shows a persistent gap between men and women.

(b) Gender disparities Female enrollment has grown at the primary level from 5.4 million in 1950-51 to 46.8 million in 1994-95 **(Figure 6)** and at the upper primary level from 0.5 million to 15.8 million **(Figure 7)** (Ministry of Human Resource Development, 1995). The rate of growth of enrollment for girls has been higher than boys, but as with other educational indicators, gender disparities are conspicuous in regard to enrollment and retention, which is evident is the fact that girls still account for only 45 7 percent of the enrollment at the primary stage Girls have a higher dropout rate than boys at both the primary and upper primary level (ibid.).

4 3 Nutrition

The adequacy or other wise of food for groups of persons can be judged by comparison of the calorie intake of the different groups with recommended allowances for concerned groups. The calorie requirement for India, based on lifestyle and climatic factors, is 2150 kCal/day (UNDP, 1995). The Indian Council of Medical Research (ICMR) and other institutions, in the 1950s and 1960s, undertook comprehensive, highly specific and goal-oriented nutritional studies These studies helped in understanding the nature, extent, and the casualty of different types of malnutrition prevalent in the country. The results of the studies also enabled nutrition scientists to formulate a number of realistic and problem-specific intervention programs and to devise appropriate strategies for their implementation (Rao et al., 1989) In recent years, the result of these programs has been a gradual increase in calorie intake from 2197 in 1984 to 2395 in 1992 (Ministry of Health and Family Welfare, 1993).

This change in the mean energy intake level is further corroborated by corresponding changes in the distribution of house holds with different levels of energy intakes.

4.4 Health

During the four decades, India has experienced a marked expansion in the number of registered physicians, from less than 62,000 in 1951 to almost 400,000 in 1991. At the same time, this translated to a increase in the number of physicians per million persons from 170 to 480 **(Figure 8)** (ibid , 1993) As a result of this growth in the infrastructure and personnel for health care, there is a clear indication of an improvement in the state of health in India The improvement over the years becomes clear with the examination of deaths from cholera, which have fallen noticeably from about 20,000 annually in the late 1950s to fewer than 100 in 1993 **(Figure 9)**.

However, despite this improvement, Indian survival standards are comparable to those of many of the poorest nations Malaria provides us with an apt illustration It has spread to cities and small towns despite eradication programs that exist in 122 Indian towns (VHAI, 1992). Urban malaria has been linked to monsoon-flooding as well as the general lack of sanitation. Slum dwellers living in flood-prone areas are especially vulnerable to the urban malaria. To combat this, a national malaria eradication program was launched in April 1958 with the broad objective of reducing malaria related deaths to less than 0 5 API (annual parasite incidence per 1000 population) by the year 2000. Although its goal has not yet been reached, there has been an improvement from 4 5 API in 1981 to 1.9 in 1990 (ibid.).

4.5 Agricultural production

(a) Rice Rice is cultivated on 42 million hectares and represents 43 percent of total food grain production in India (HSIA, 1995) The country has witnessed a progressive growth in rice production from a mere 20 million metric tonnes in 1950 to a record 81 mmt in 1994 at a annual growth rate of 3.2 percent **(Figure 10)** (ibid.). This increase corresponds to growth in production from 668 kg/ha in 1950 to 1879 kg/ha in 1994 due to technological developments, like the introduction of high yielding varieties and their effective dissemination. The demand for rice is expected to increase to 95-100 mmt in the next five years and to 120-125 mmt in the decade beyond. To achieve this requires that the crop productivity be further increased to 2470 t/ha and 3500 t/ha by 2000 and 2010 respectively (ibid.).

(b) Wheat Wheat production, which was only 10.4 mmt in 1965/66, increased to a record level of 60 million metric tonnes in 1994 **(Figure 10)**, and currently amounts to one-third of the total food grains production (HSIA, 1995). High yielding varieties (HYV) represent

about 87 percent of the area under wheat cultivation, and area under wheat is increasing at an annual level of 1.7 percent compared to 0.5 percent for rice HYVs and irrigation coverage have reached almost a saturation level in the wheat growing belt of India The low growth rate during the past seven years (1.5 percent) indicates that a wheat yield plateau has almost been reached and further increases in production can only be expected through the consumption and efficient use of fertilizers The demand for wheat is expected to increase to 95 mmt by 2020 (ibid.)

(c) Maize. Maize is one of the major coarse cereal crops of India. The production has increased from 5 7 million metric tonnes in 1968 to 9.3 mmt **(Figure 10)** (CMIE, 1995)). The low growth rate recorded for maize may be due to the fact that it is a rain-fed crop has seen a declining area during 1980s.

(d) Total food grain The total food grain production in India has increased from just 51 million metric tonnes to a remarkable production of 185 million metric tonnes in just four decades (HSIA, 1995) This progress during the last 40 years can be attributed to the development of improved production technologies, the development of an efficient input production and delivery system, and advances in agrarian reform, rural infrastructure development, input and output pricing policies and marketing arrangements However, with continued increases in population, demand for food grains is projected to be 240-245 mmt in 2000 and 400 mmt in 2035 (Bali, 1994). Even with additions of farmland through wasteland reclamation, productivity will have to double to 27 quintals/ha to be able to meet this demand (ibid.). Due to limited further gains in irrigation productivity, the necessary increases in food grain output may have to come from increases in rain-fed land productivity.

4 6 Milk and egg production

(a) Milk. The last 20 years have seen an impressive rise in India's milk production. Beginning with 17 mmt in 1950, it stagnated at around 20 million metric tonnes until 1970/71, before surpassing 70 mmt in 1995 (HSIA, 1995) This increase is largely due to the introduction of exotic high milk yielding cattle and buffaloes, cattle improvement through crossbreeding, infrastructural development for animal health and supply of inputs, and the initiation of Operation Flood in 1969 to develop a sound marketing system through the organization of milk producers cooperatives The productivity of dairy animals has increased from 596 kg/lactating animal/year in 1951 to 987 kg/lactating animal/year in 1993 (ibid.). Despite the fact that productivity is increasing, the productivity of milk per animal in India is much lower than that in many other countries (like 6273 kg in Denmark or 6092 kg in Japan).

The major constraints for higher productivity are the availability of feed resources and poor extension services.

(b) Eggs The progress of the Indian poultry industry over the past two decades has been remarkable by any measure Egg production has crossed the 30 billion mark in 1995, making India the fifth largest egg producer in the world (HSIA, 1989). During the past three decades, poultry farming has transformed itself from a backyard activity into an organized, sophisticated medium-scale industry The industry is growing at a rate of 7.6 percent every year. The National Commission on Agriculture has estimated that the demand for eggs by 2000 will be 36 billion (ibid.), which appears to be achievable at the present rate of growth.

4.7 Fish production

Inland and marine fish production increased consistently between 1951 and 1981, after which marine production has continued to increase, but inland production has fallen from 1.06 mmt in 1981 to 0.75 mmt in 1991 **(Figure 11)** (Shingran, 1970).

4.8 Fertilizer consumption

In India the total NPK (nitrogen, phosphorus, potassium) consumption increased from 0 06 million metric tonnes in 1952 to 1.1 mmt in 1966/67, an annual growth rate of 21 percent (CMIE, 1995). In the subsequent three decades, fertilizer consumption has continued its growth at 9.5 percent annually, making India the fourth largest consumer in the world The results of this substantial increase in fertilizer consumption are noticeable, e g., rice paddy production more than tripled over the same period **(Figure 12)**

Nevertheless, experiments have shown that only 23 percent of nutrients removed from soil by crops comes from fertilizers (Tandon, 1992) So there is an urgent need to increase the efficiency of fertilizers in soil In the face of limited land availability and growing land degradation problems, meeting the food requirements of an ever-increasing population will necessitate the consumption of fertilizer for crop production to increase to 22 mmt in 2000 (CMIE, 1995).

4.9 Land use and degradation

Out of India's total geographical area of 329 million hectares (mha), only 305 mha is the reporting area (the remaining area is unadministered for various reasons). About 21 mha is occupied by housing, industry, and other non-agricultural uses, 19.5 mha area is snowbound and remote, and 264 mha remains for agriculture, forestry, pasture, and other biomass production. Since 1950, about 27 mha has been added to forest area, mostly through

replacing private forest lands with *zamindars* (large-holding landlords) (Bali, 1994). The net area sown increased from 119 mha in 1950/51 to 140 mha in 1970/71, mostly through the reclamation of old fallow and cultivable wastelands and diversion of groves. However, since 1970/71, the net area sown has remained at this level, indicating a limit to private efforts and suggesting government intervention for further land reclamation. The scope exists for the addition of about 10 mha through the reclamation of cultivable wastelands like ravines, saline alkali soils, and waterlogged areas (ibid.).

During the last ten years, there has been no change in the major classification categories of aggregate land use, namely, Forest and Woodland, Meadows and Pasture, Cropland, and Other. The average distribution of these categories is shown in **Figure 13.** During the eight year period for which data were available, cropland has covered almost half of Indian land. Although the total area of cropland has remained constant, the proportion of it fed by irrigation has risen from 42 million hectares to 45.8 million, while rain-fed cropland has fallen from 86 6 million hectares to 80.5 million (CMIE, 1995)

This increase in irrigation can perhaps be the reason for the increment in total salt affected land, which has grown from 7.18 million hectares in 1987 to over 10 million in 1993. In general, India has experienced an expansion of degraded land area from 130 million hectares in 1987 to 188 million in 1993.

4.10 Forest resources

(a) *Afforestation* The planned economic development of the country started in the year 1951 with the First Five Year Plan, which envisaged afforestation for the purpose of soil conservation (Planning Commission, 1951). Subsequently, a National Forest Policy was introduced, emphasizing the need to expand the forest cover to a minimum of 33 percent of the total geographical area In 1956 (Second Five Year Plan), the afforestation of industrial economic species and plantations of fuelwood and fodder trees were undertaken (Planning Commission, 1956). In the Third Five Year Plan, plantations of fast-growing species were started (Planning Commission, 1961). By 1970, many other schemes of plantations had been introduced, later becoming an integral part of the planned developmental activities (Planning Commission, 1970/71). In the past, forests were leased out to contractors and wood-based industries, but in recent years, public undertakings, in the form of forest corporations, have been established by each State Forest Department to take over extraction

(b) *Roundwood Production* Historical data reveal that there has been a 196 percent increase in roundwood production in 1993 as compared to that of 1964 **(Figure 14).** The largest increase occurred between 1970 and 1980, when roundwood production grew by 93 percent, largely as a

result of the clearing of miscellaneous forests for industrial plantations and of production from plantations created during the Second Five Year Plan period. Between 1980 and 1990 there was a further 28 percent increase, followed by little change in the early 1990s. This indicates that there is little probability of any significant increase in roundwood production in the coming years. The population is increasing by 24 percent per decade with no further change in the area under potential productive forests, thereby increasing the probability of the shortage of roundwood production in the country (Planning Commission, 1992).

(c) *Fuelwood and Charcoal Production* A similar trend has been seen in fuelwood and charcoal production **(Figure 14)**. Since 1964, there has been a 194 percent increase in fuelwood and charcoal production. The largest portion (104 percent) occurred between 1970 and 1980 which may be attributed to the introduction of fuelwood species during the Second Five Year Plan period As with roundwood, there was a modest increase in fuelwood and charcoal production during the 1980s and a stabilization in the 1990s. However, persistent population growth has led to a wide gap between the demand and supply of fuelwood and charcoal In addition to official production, this deficit is met through supply from wood lots and other unrecorded sources, which are becoming more scarce The demand for fuelwood is likely to continue growing in pace with future increases in population, and it is estimated that by the year 2010, demand for fuelwood and charcoal will exceed 33 million cubic meters.

Historical production figures fail to indicate future gains in fuelwood and charcoal production. Consequently, shrinking forests combined with population increases will cause the gap between demand and supply of wood to widen rapidly The situation will necessitate new technologies and management strategies for increasing the productivity per unit basis

4.11 Tourism

Tourism in India, although still relatively under-developed, is on a significant rise and the indications are that the trend will continue. The contribution of tourism industry to the Indian economy has been seen in terms of foreign exchange earnings. In the last three decades, i.e. from 1971 to 1991, the earnings have increased from Rs 45 crores to 2444 crores (DES, 1995), and the number of foreign visitors has increased from 301,000 to 1.68 million each year **(Figure 15)** (CSO, 1992)

4.12 Municipal solid waste

Municipal solid waste is a heterogeneous mixture of paper, plastic, textiles, garbage, metals, glass, dust, cinders, etc The proportions of these constituents vary from season to season and

place to place depending on lifestyle, food habits, standard of living, and degree of commercial and industrial activity.

With the rapid increases in population, the generation of solid waste in cities has increased several-fold during the last few years. At the level of the municipality, the quantum of waste generated varies across urban centers, depending to some extent on the population, the degree of industrialization, and consumption patterns in the center The per capita waste reaching disposal sites is about 0.5 kg/capita/day in Bombay and Calcutta (Bhide et al., 1983). In the 3 cities of Andhra Pradesh, the per capita values are more or less equal and range between 0.17-0.2 kg/capita/day. In Hyderabad the per capita value is 0.33 kg/capita/day, with observations ranging from 0.15 to 0.35 kg/capita/day (ibid).

Very few reliable statistics on solid waste generation are available at the national level. In the year 1984, the national per capita generation of waste was estimated to be 250 grams/day (Holmes, 1984). Since these were the only national-level solid waste data available, the per capita quantities for the other years were linearly extrapolated assuming a 1 percent annual growth rate (Nath, 1984) for previous decades and 1.33% (Planning Commision, 1995) for the 1990s and the future. On the basis of the population of Indian urban centres, the total MSW generation in these areas has been estimated and is shown in **Figure 16.**

4.13 Transportation

Rapid urbanization, along with the rise in industrial and commercial activities, has increased the demand for transport As a result, transport infrastructure has expanded considerably in terms of network and services over the last four decades.

(a) *Roadways* The role of road transport has been very impressive, as it is by and large the only means of transport available in the hilly, rural, and backward areas. The total length of Indian roads has increased fivefold from 400,000 km. in 1950/51 to 2,103,000 kms in 1990/91, whereas the number of vehicles has grown 70 times, from about 0.3 million to more than 21 million during this period **(Figure 17)** (MST, 1993). Road traffic accounts for nearly 80 percent of passenger traffic and 60 percent of goods traffic. The number of vehicles per 1000 population has increased from 0.85 in 1951 to 25 31 in 1991 and it is expected to exceed 40 by the year 2000 **(Figure 18).** The bulk of this vehicular population is found in urban centers, with about 35 percent concentrated in the 23 metropolitan areas. Delhi itself accounts for more than 8 percent of the total registered vehicles. Of the total 25 million vehicles during 1993, about 80 percent are personal modes of transport, with the share of two-wheelers and cars at about 68 percent and 12 percent respectively (ibid.).

The growth of motor vehicles in India has been faster than the population growth. The total number of motorized vehicles has grown at an annual rate of about 13 percent. During the last two decades, the number of two-wheelers has grown at the rate of 17 percent, intermediate modes of transport (i.e three-wheelers and taxis) at the rate of 13 percent, buses and cars, at 7 percent, and goods vehicles at 10 percent. The share of diesel-driven vehicles (mainly buses and trucks) grew at an annual rate of 9.5 percent during this period (ibid.).

(b) Railways **Figure 19** indicates the growth of railways in India The rail network presently extends over 62,660 route-kilometers Between 1950/51 and 1994/95, the total passenger traffic increased from 66.5 billion to 319 billion passenger-km and freight traffic from 37.5 to 253 billion tonne-km (Indian Railways, 1994/95) The number of diesel engines has grown from 17 in 1950/51 to 4259 in 1994-95. The corresponding growth in electric engines has been from 72 to 2302, while the number of coal engines has declined from 8120 in 1950/51 to 347 in 1994/95 (ibid.). Thus, there is a clear shift from steam locomotives to diesel locomotives, furthermore, diesel use in railways would increase substantially due in the event of a complete phase out of coal before the next century.

4.14 Fossil fuels production and consumption

(a) Coal Until the year 1956, coal production in India was the responsibility of the private sector. In 1956, the public sector was given control in order to bring in new technologies and to accelerate the growth of the industry The government opened large opencast mines, the result of which was a jump in production from 32 million to 55 million tonnes in 1960 (Ministry of Coal, 1995) Continued nationalization in the 1970s led to an annual growth rate in coal production of 4.5 percent, and the growth rates in subsequent years have continued to meet or exceed that level **(Figure 20)** (ibid)

The consumption of coal in closely tied to its supply, i.e. little coal is either imported to India or exported. As a result, as the figure shows, the lines describing coal production and consumption are very similar

(b) Crude Petroleum and Natural Gas The discovery of the Bombay High Offshore fields in 1976 was the turning point in India's oil and natural gas production history. Since then, Bombay High has been India's chief oil producing region. As a result of this discovery, crude production grew at a compound annual growth rate of about 10 percent between 1976/77 and 1984/85. The fastest rate of growth was achieved during 1981/82 to 1985/86 when the level was almost 17 percent However, following this, the growth rate fell, and

between 1991/92 and 1993/94, oil *production* actually fell, due to the aging of existing fields and delays in finding and opening new ones (**Figure 21**) (Ministry of Petroleum, various issues). However, as a consequence of the discovery of several non-associated natural gas fields, this gas showed a continued slow increase during this period

Although the annual production of crude oil has fallen off in recent years, the consumption of these fuels has continued its strong growth. Thus, in the period following 1983, the demand for crude petroleum imports has grown noticeably.

4 15 Water Quality

(a) *Surface Water Quality* For most Indian rivers, the observed purity falls well-below that which is desired for health and environmental reasons According to a study of the water pollution in the Ganga basin (which forms the major focus of the Ganga Action Plan of India (GAP)), it is estimated that three-fourths by volume of the waste water entering the rivers is generated from municipal sources (World Bank, 1996). Moreover, for Class I cities of India, less than five percent of the total waste water generated is collected and less than one-fourth of this is treated. Thus, untreated sewage and other non-industrial wastes are the major cause of river water pollution, accounting for four times as much pollution as industrial effluents (ibid.).

Water quality statistics generated by the monitoring network since 1980 can be used to assess trends in water quality during the regulation period. Concentrations available for the monitoring points were compared with the CPCB standards, and the frequency of violation of the standards was examined. The standard used for this comparison is that specified for a drinking water source after conventional treatment, i e., 3 mg/liter for biological oxygen demand (BOD), and 5000 MPN/100 ml (most probable number per thousand milliliters) for coliforms (Sankar et al., 1992). **Figure 22** and **Figure 23** show pollutant concentrations for the river Ganga and all other rivers of India. The trends show that while there has been improvement in the BOD concentrations of river Ganga, total coliforms concentrations in other GAP rivers still remain critical

Additional pressing issues related to the present status of water quality in various rivers can be summarized as,

* Increasing levels of bio-accumulation are occurring due to the inputs of domestic and industrial wastewater, as observed in the Yamuna river It has been reported that levels of heavy metal concentrations at both the stations tested are exceeding environmentally safe concentrations.
* The river Ganga is found polluted in individual stretches as long as 480 km.
* The river Yamuna is deemed 'clean' only in 522 out of its total length of 1044 km.

* Among the four primary parameters, pH, dissolved oxygen (DO), BOD, and total coliforms, required to classify river stretches from A through C, total coliforms is observed to be the most critical parameter followed by BOD

(b) *Groundwater Quality* The two major concerns relating to groundwater quality are excessive extraction without commensurate recharge and the leaching of pollutants to the aquifers. A survey of groundwater quality at 138 sampling locations in 22 industrialized zones was conducted in 1994 to assess levels of contamination. The groundwater at these locations was analyzed for all major parameters, including heavy metals, physico-chemical parameters, bacteriological parameters, and pesticides It was observed from the detailed findings that the water in all 22 areas was not fit for drinking purposes (CPCB, various years). Bacteriological contamination was observed in almost all the samples. Heavy metals including poisonous metals such lead and mercury was found in two wells

4.16 Air Quality

India has witnessed significant degradation of air resources in the last two decades. Increasing urbanization and industrialization are some of the major problems causing severe air pollution and associated effects in the country. Although industrial pollution is one of the major causes, the toxic nature of the air pollutants and their high concentrations in many industrialized regions of the country are posing serious concern Air quality data in India's major cities indicate that ambient levels of suspended particulate matter considerably exceed the World Health Organization and National Ambient Air Quality Standards of India. For instance, while the WHO standard for suspended particulate matter is 150 mg/m^3, the average levels of suspended particulate matter in the four metropolitan cities exceed 360 mg/m^3 (Srinivas, 1996). Sulfur dioxide and nitrogen oxide levels in these major cities fall well-within the prescribed standards, but are increasingly becoming a matter of concern, due to the rapid rise in the number of motor vehicles (ibid.).

An estimated 2000 metric tonnes of air pollutants is emitted into the atmosphere every day in Delhi. Vehicular sources contribute about 64 percent of total pollutants emitted, followed by thermal power plants, 16 percent, industries, 12 percent, and 7 percent from the domestic sector (TERI, 1996).

The industrial and transportation sectors emerge as two large sectors contributing to pollution The production of automobiles in India has increased from 1891 in 1955 to 2,800,000 in 1994. Two- and three-wheelers constitute 75 percent of the total vehicles and cause more than 50 percent of the total pollution (ibid.).

In the industrial sector, fossil fuels, particularly coal, are one the major sources of energy input. About 60 percent of the country's commercial energy is produced from coal and lignite. Coal will continue to play a predominant role in the energy expansion program and thus increasingly contributed to particulate air emissions apart from principal Greenhouse Gases (GHGs).

Trend analysis and projections (**Figure 24** and **Figure 25**) show that there will be a considerable rise in air emissions over the next two decades (TERI, 1992). This signifies that more comprehensive measures to tackle air pollution must be adopted and implemented to protect the environment

4 17 Carbon Dioxide emissions

India has observed rapid increases in the emissions of carbon dioxide in the recent past. Since 1950, there has been an increase of 5.9 percent each year Total emissions have increased by 10.4 times during this interval, and per capita emissions have increased almost 4 times (Marland et al , 1994. The level of emissions is closely correlated with Gross National Product, which follows the logic that economic growth is achieved through increased energy consumption **(Figure 26)**. These emissions are largely contributed by coal burning in India. Coal contributed 87 percent of the emissions in 1950 and 71 percent in 1991; at the same time the oil fraction of CO_2 emissions increased from 11 percent to 22 percent (ibid.).

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Appendix 1

Figure 1
Historical population trends

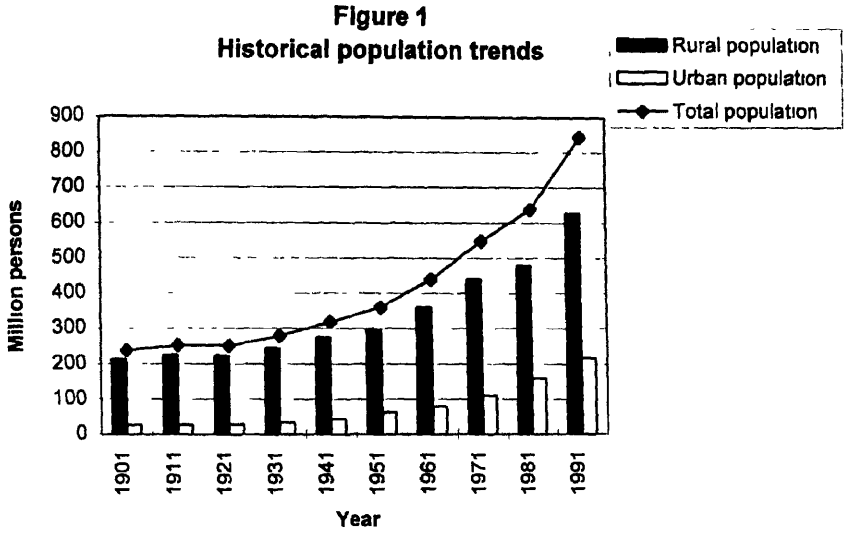

Figure 2
Historical trends in Births and Deaths

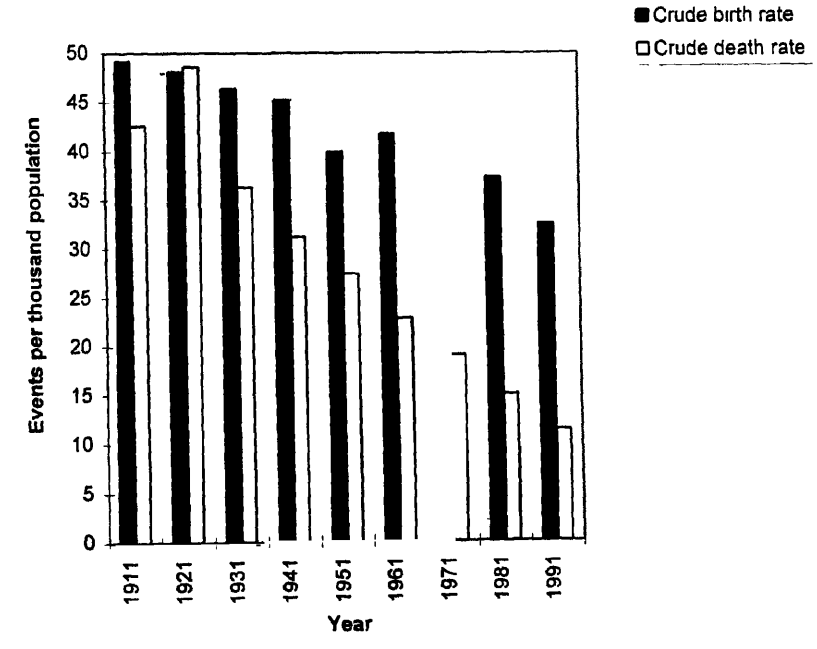

Figure 3
Average life expectancy

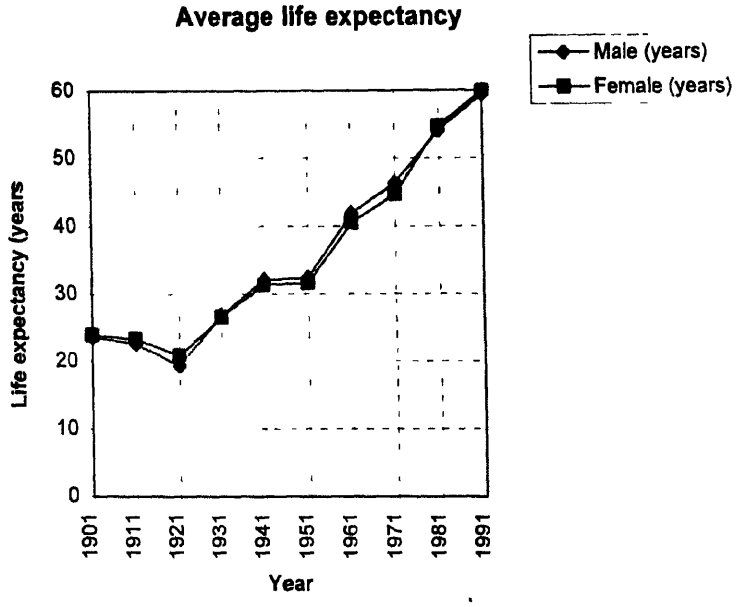

Figure 4
Percent school enrollment for the period 1950-1995

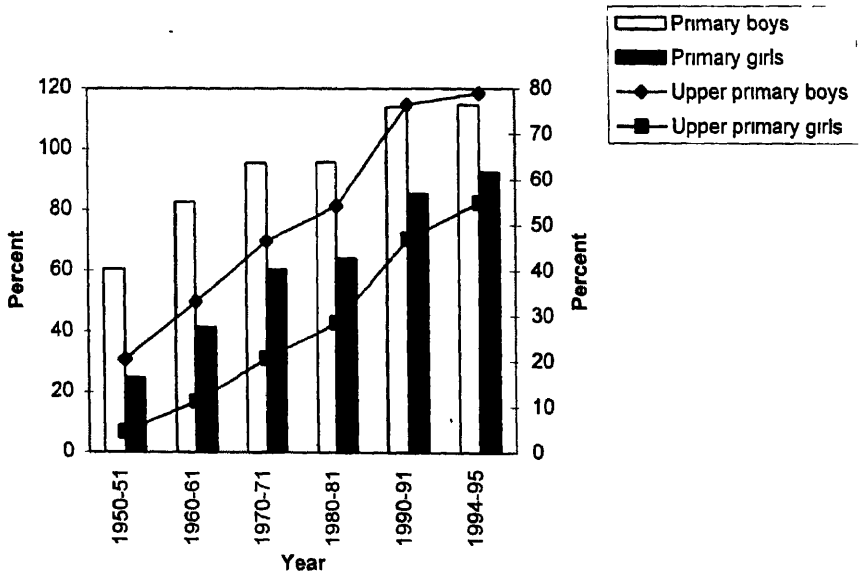

Figure 5
Historical literacy rates

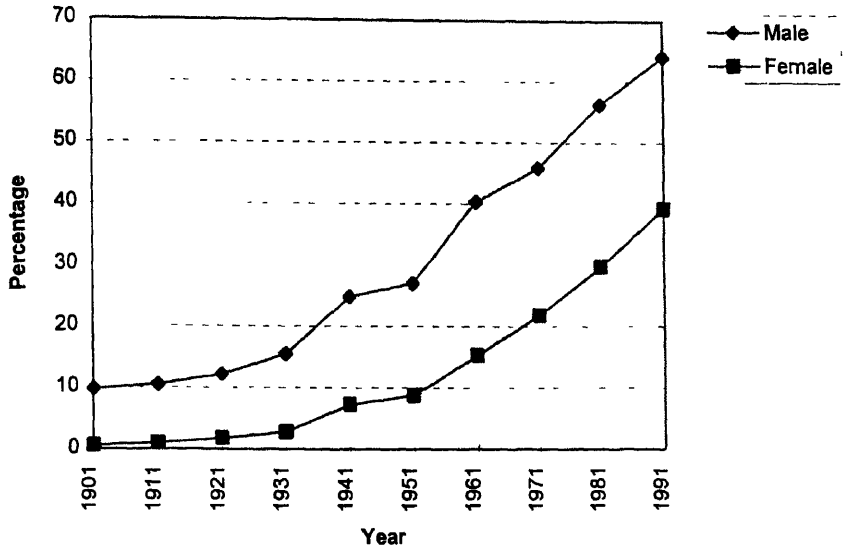

Figure 6
Decadal primary school enrollment from 1950-1995

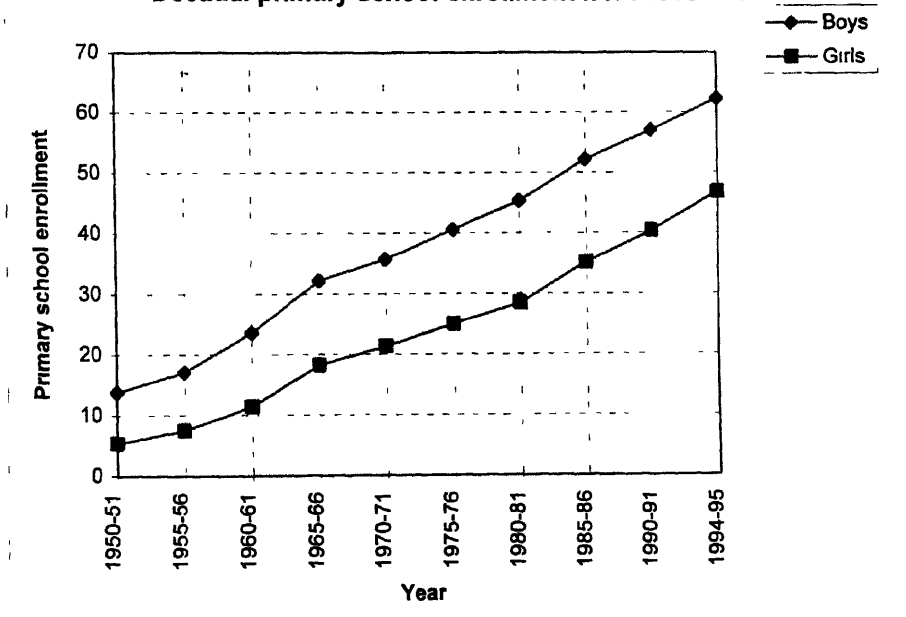

Figure 7
Decadal upper primary school enrollment from 1950-1995

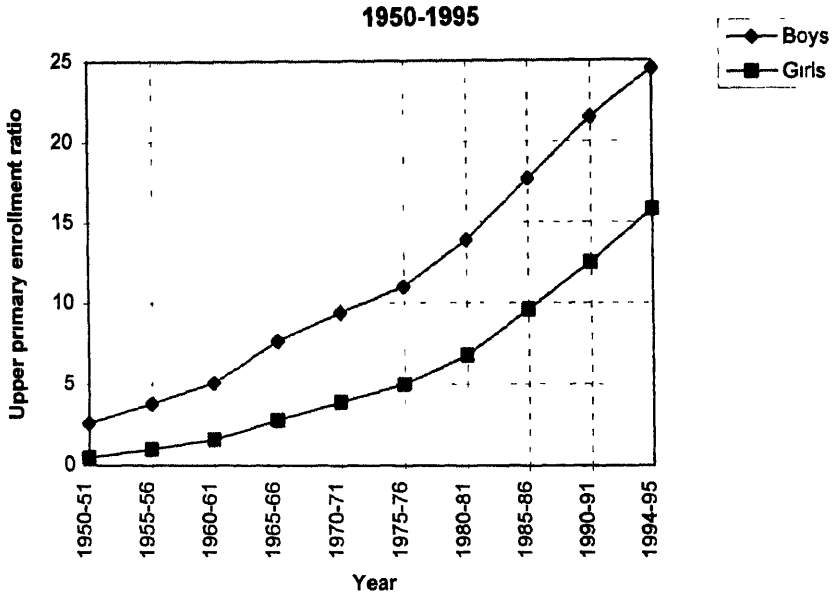

Figure 8
Number of medical practitioners

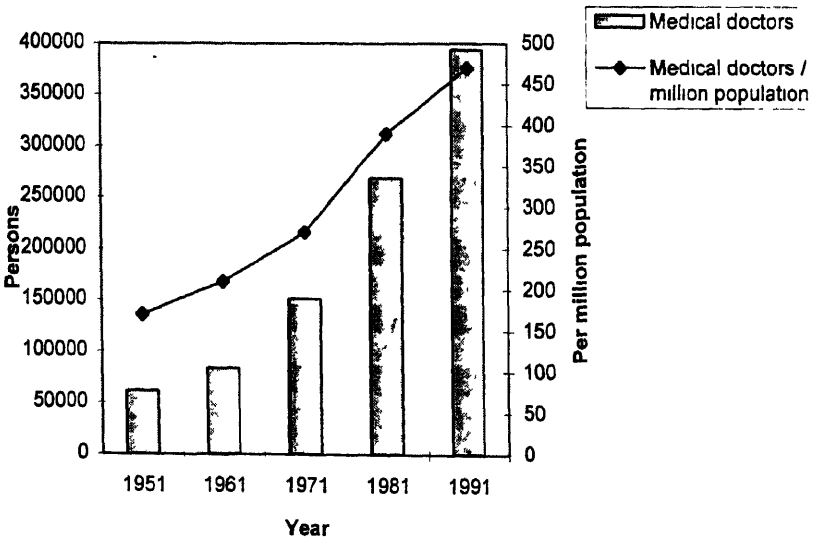

Figure 9
Cholera incidence from 1956 to 1993

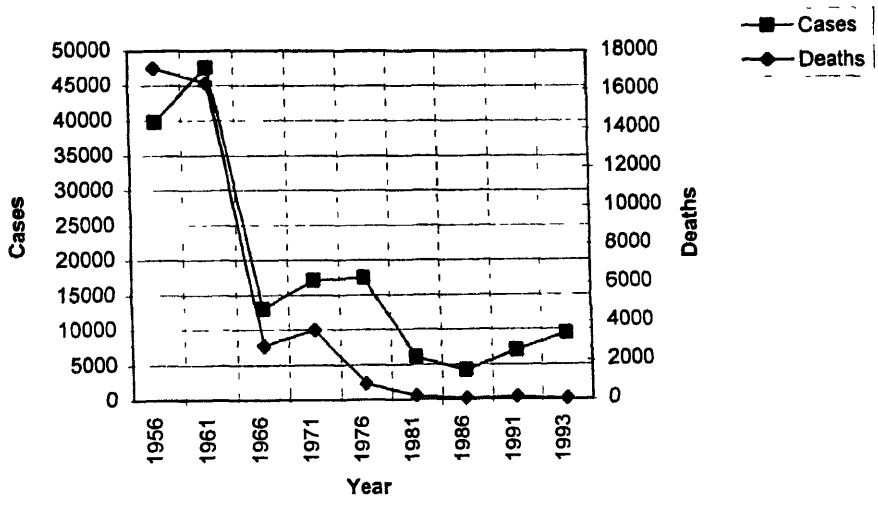

Figure 10
Agricultural production from 1950-1990

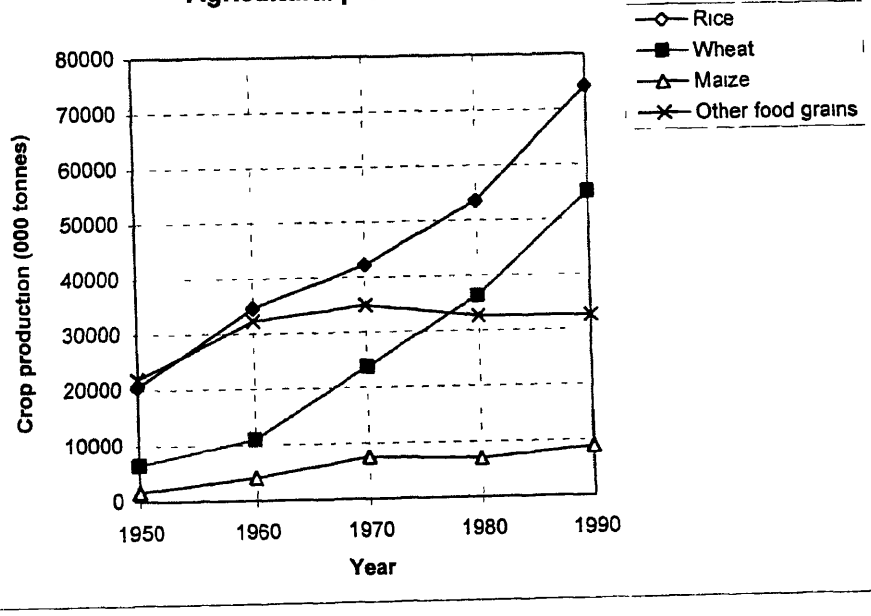

Figure 11
Fish production from 1951-1991

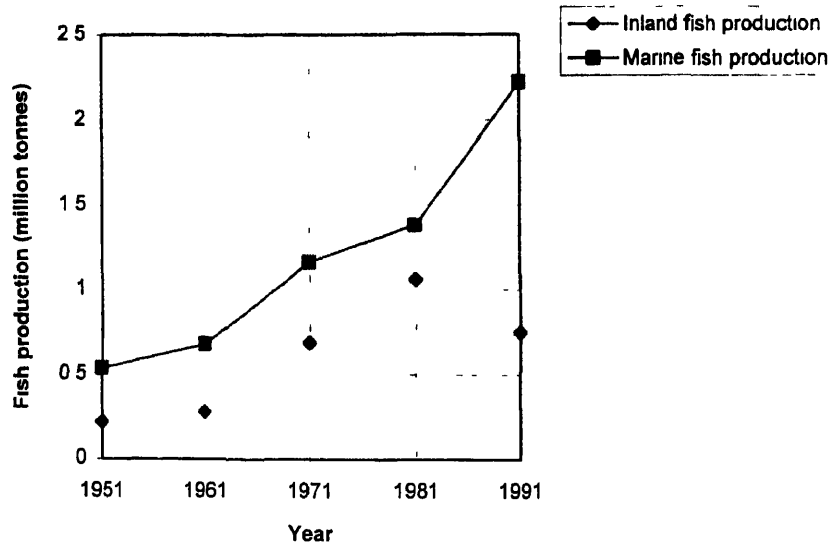

Figure 12
Fertilizer consumption vis-à-vis rice production for 1951-1991

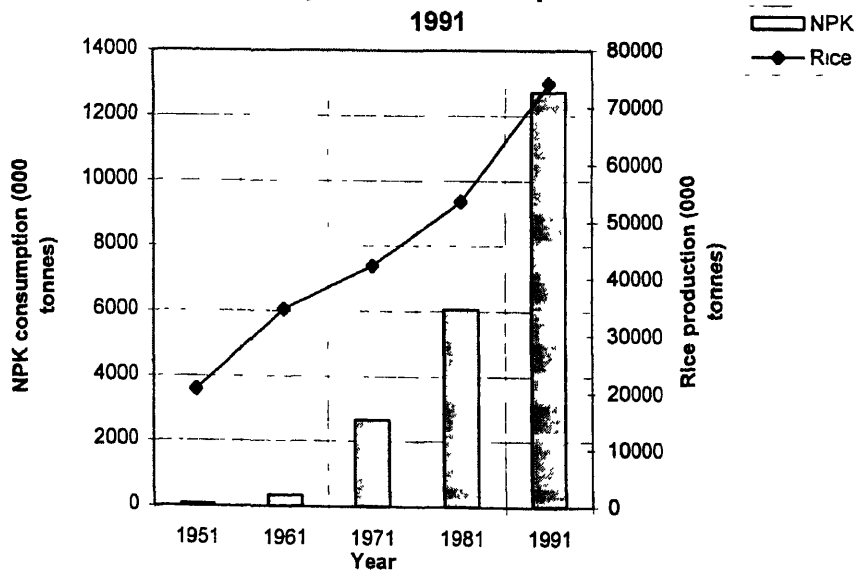

Figure 13
Percentage use of Indian Land (1984-1991)

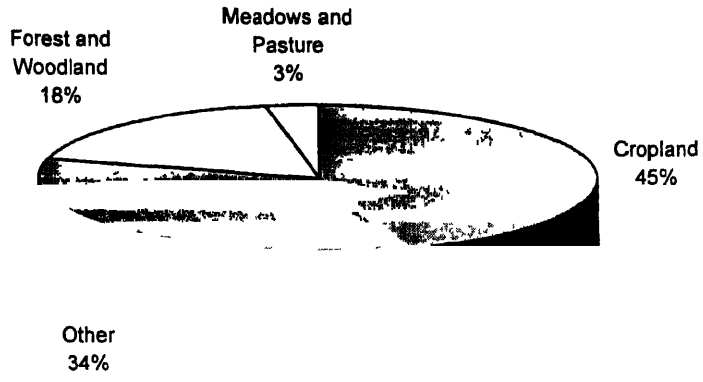

Figure 14
Roundwood and fuelwood production from 1964 to 1993

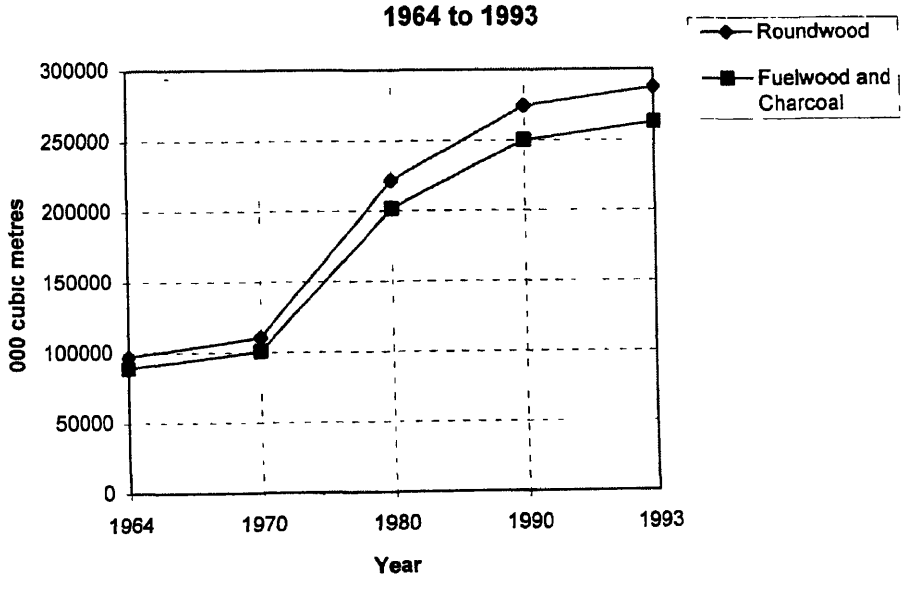

Figure 15
Foreign tourists vis-à-vis foreign exchange

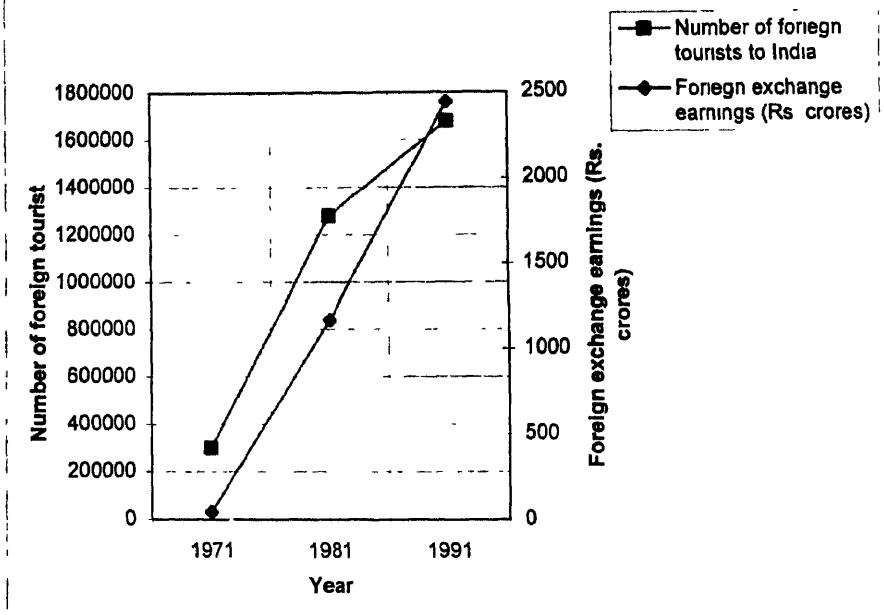

Figure 16
Trends and projections in municipal solid waste generation in urban centres

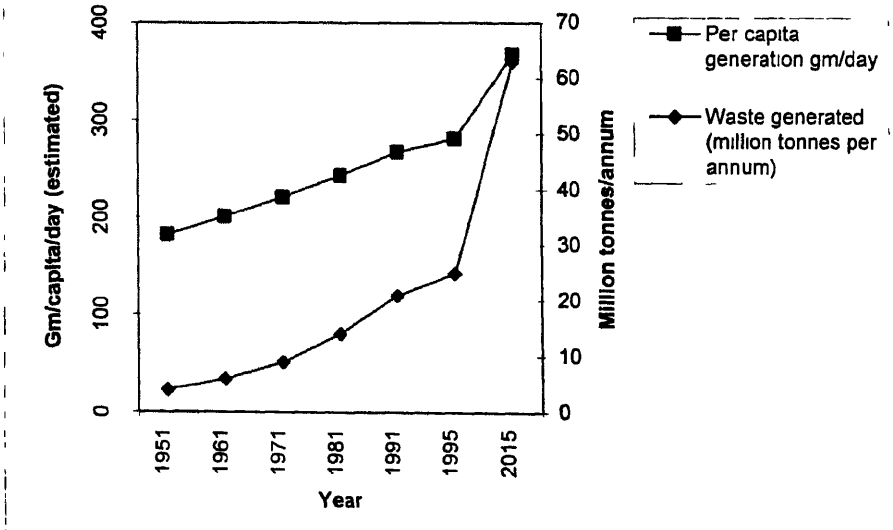

Figure 17
Road length vis-à-vis number of vehicles

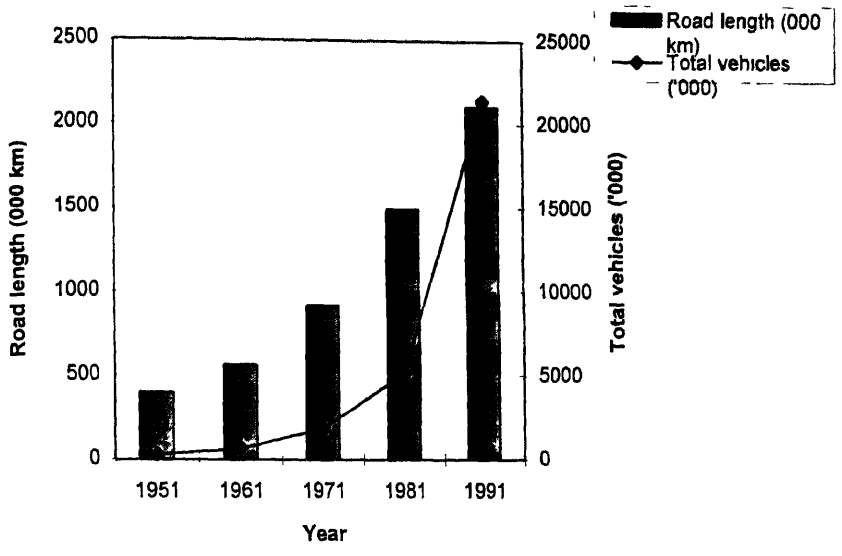

Figure 18
Share of personal vehicles

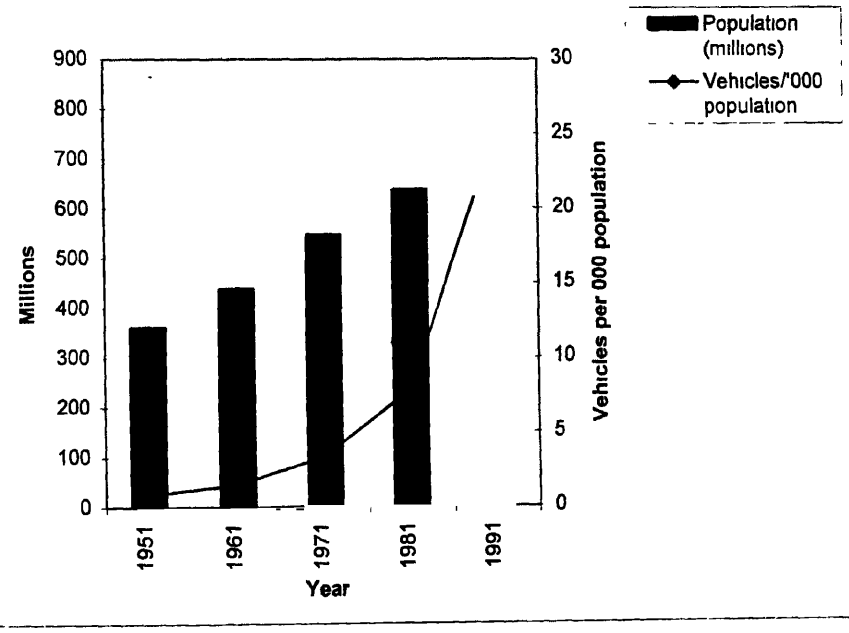

Figure 19
Growth in railways from 1951 to 1994

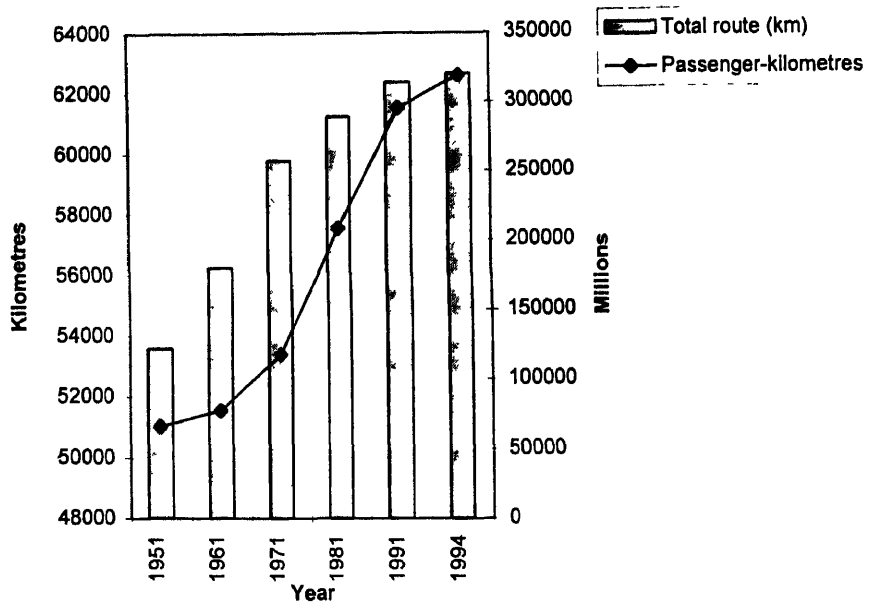

Figure 20
Coal production and consumption

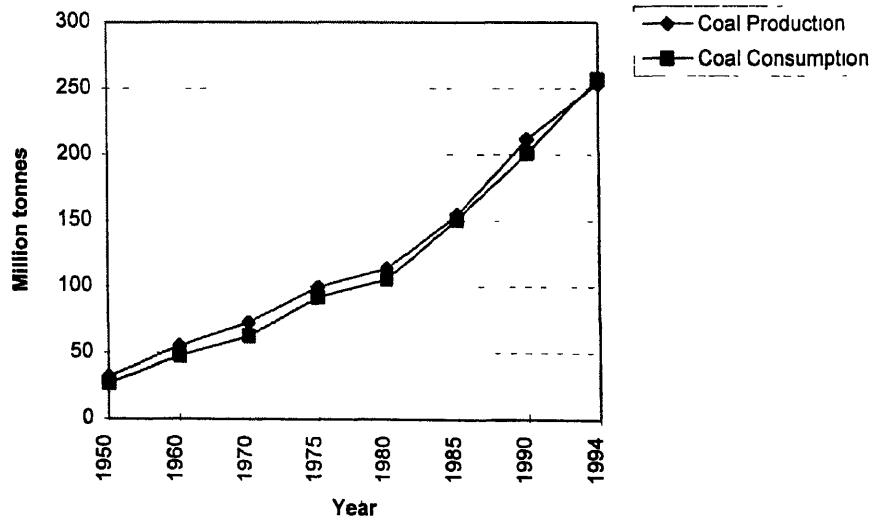

Figure 21
Crude oil production and consumption

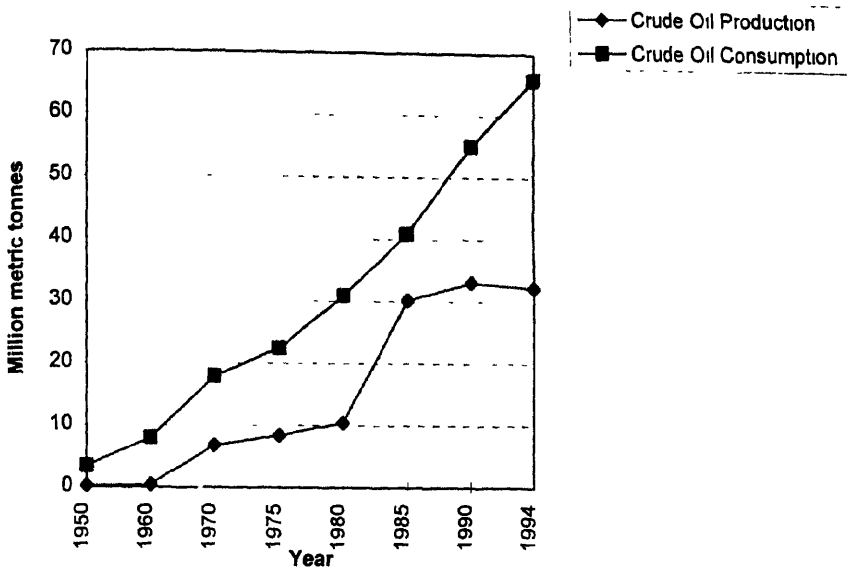

Figure 22
BOD concentration

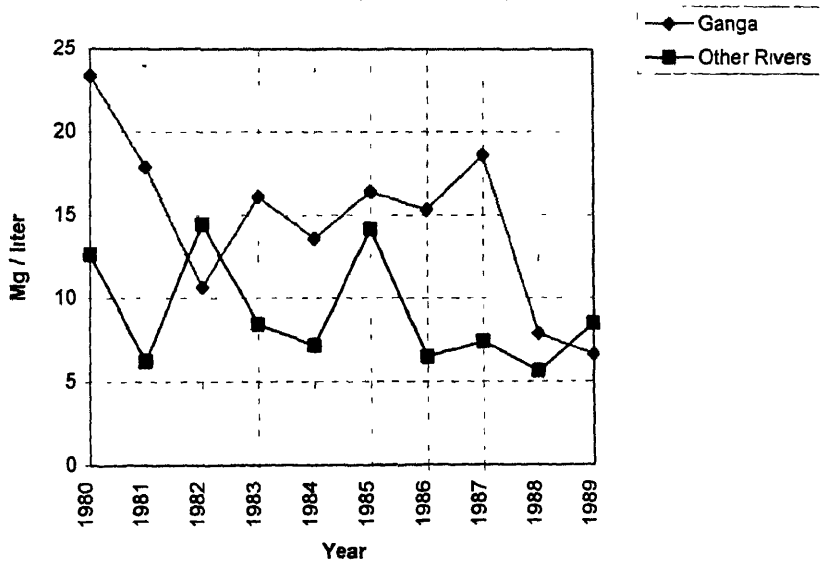

Figure 23
Coliform concentration

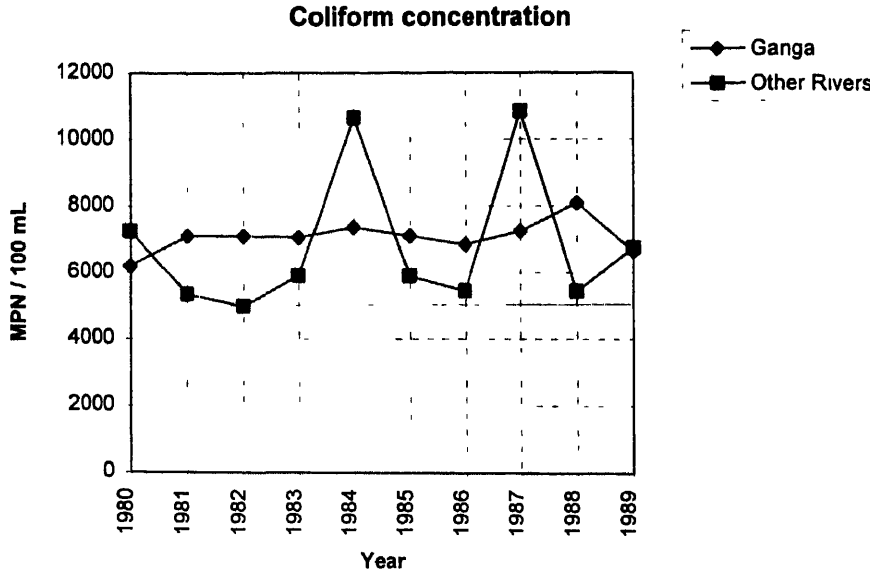

Figure 24
Trends and projections in the emissions of Suspended Particulate Matter

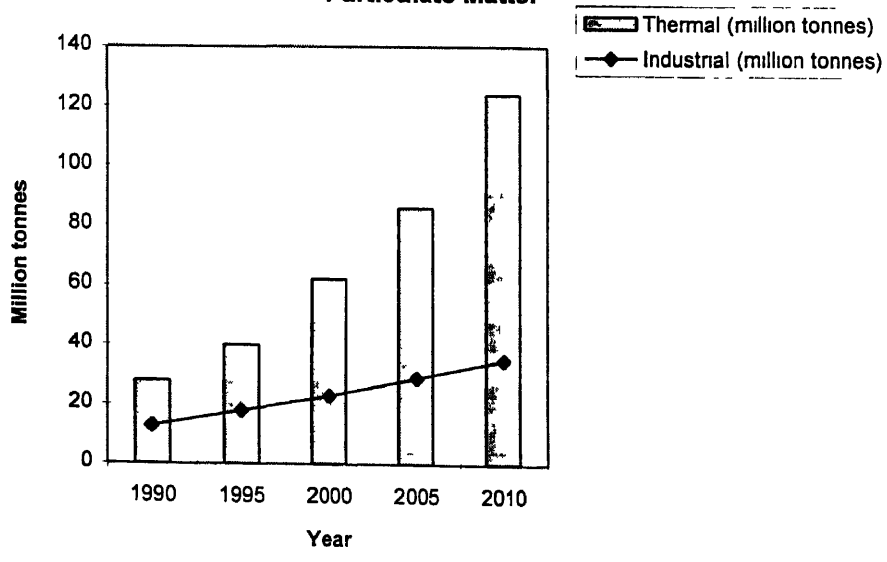

Figure 25
Trends and projections in the emissions of sulphur and nitrogen oxide

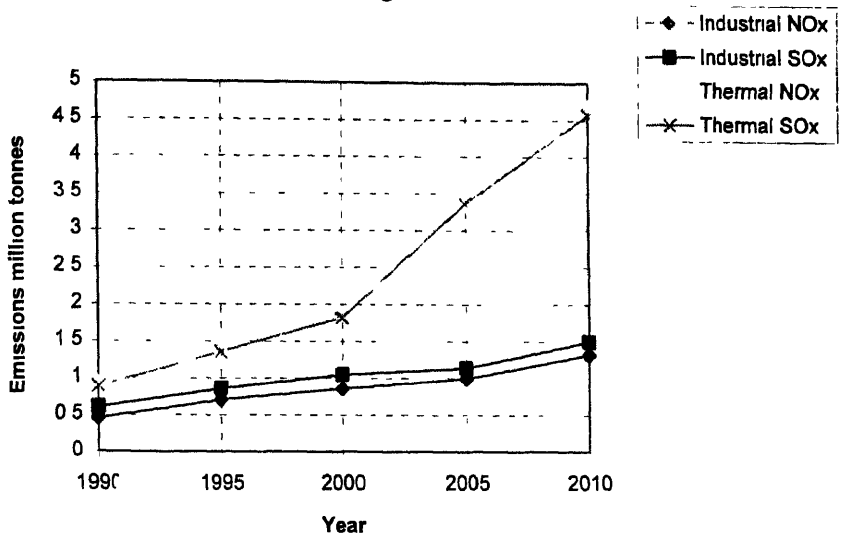

Figure 26
CO_2 emissions from 1951 to 1991